DRAFT

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3D Interpolation and Mosaicking of Radar Data Fields

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1. Introduction

Several objective analysis schemes are under testing for mapping radar data fields onto a three-dimensional regular Cartesian grid. The grid is uniformly spaced in the horizontal. Vertical grid spacing can be uniform or stretched. Grid configuration parameters (e.g., location and size of the analysis domain; horizontal and vertical resolutions of the grid mesh) are adaptable and can be easily adjusted.

Three experimental interpolation schemes have been coded: (1) a radar bin volume mapping, (2) a uniform Barnes, and (3) an adaptive Barnes. New schemes involving multi-pass remapping and interpolation will also be tested.

A scheme for three-dimensional mosaicking of multiple-radar data fields is also under development. Following sections describe the interpolation and mosaicking schemes in more detail.

2. Radar bin volume mapping

In this scheme, a value at any given radar bin is simply assigned to all grid points whose centroids are within the radar bin volume. Grid points whose centroids are not within any radar bin volume are flagged as missing.

3. Uniform Barnes interpolation

The weighting function in the uniform Barnes scheme is defined as:

$$w = \exp\left[-\frac{(x_g - x_o)^2}{\kappa_h} - \frac{(y_g - y_o)^2}{\kappa_h} - \frac{(z_g - z_o)^2}{\kappa_v} \right] \tag{3.1}$$

The analysis value at any specific grid point is calculated using

$$f_g = \frac{\sum_{k=1}^{N} w_k \quad f_o(k)}{\sum_{k=1}^{N} w_k} \tag{3.2}$$

Where w is the weight given to a radar observation; (x_o, y_o, z_o) are the Cartesian coordinates of the observation and (x_g, y_g, z_g) are the coordinates of a grid point. f_g

represents the interpolated data value at the grid point, and $f_o(k)$ represents the data value at the k^{th} radar bin that is within the influence region of the grid point. N is the total number of radar bins within the influence region. κ_h and κ_v are smoothing factors that control the filtering effects in the analysis fields. By assuming uniform data distributions, a Barnes response function can be derived. The response function corresponding to Eqs. (3.1) and (3.2) is

$$D(\lambda_h) = \frac{f_g(\lambda_h)}{f_o(\lambda_h)} = \exp\left[-\frac{\kappa_h}{(\pi\lambda_h)^2}\right] \tag{3.3}$$

Here D is the ratio of the amplitude of a horizontal wave of wavelength λ_h in the analysis field to that in the raw radar filed. It is seen from Eq. (3.3) that for a constant κ_h, a horizontal scale of λ_h would be filtered by the same amount everywhere in the domain. The larger the κ values, the smoother the interpolated field.

Note that in the current software, κ_h and κ_v are adaptable parameters. They are defined by users based on the desired smoothing effects.

4. Adaptive Barnes interpolation

The current adaptive Barnes scheme is defined in terms of polar coordinates. The weighting function and the analysis equation are defined by:

$$w = \exp\left[-\frac{(r_g - r_o)^2}{\kappa_r} - \frac{(\phi_g - \phi_o)^2}{\kappa_\phi} - \frac{(\theta_g - \theta_o)^2}{\kappa_{\theta v}}\right] \tag{4.1}$$

$$f_g = \frac{\sum_{k=1}^{N} w_k \; f_o(k)}{\sum_{k=1}^{N} w_k} \tag{4.2}$$

Where w is the weight given to a radar observation; $(r_o, \varphi_o, \theta_o)$ are polar coordinates (range, azimuth, elevation angle) of the observation and $(r_g, \varphi_g, \theta_g)$ are the coordinates of a grid point. κ_r, κ_φ, and κ_θ are the smoothing factors in radial, azimuthal and elevational directions. They are also adaptable parameters in the software so that they can be easily adjusted for different smoothing effects. Note that for constant κ_r, κ_φ, and κ_θ, the response function for a specific horizontal or vertical wavelength would not be the same everywhere. The resultant filtering is range and elevation dependent due to the spatial nonuniformity of the polar coordinates.

5. Mosaicking of multiple-radar fields

The mosaicked field is obtained by a weighted average of multiple radar values at any given grid point. The weight is determined by the distance between the grid point and the radar that provided the data value. Reflectivity data from closer radars receive more weight than data measured from further radars

This scheme assumes that data fields observed by multiple radars are already interpolated onto a common grid. At each grid point, if there are more than one valid radar reflectivity values (≥ 5 dBZ) from different radars, then a weighted average of the multiple values is taken as the final value at the grid point. The weight is defined using a simple Cressman weighting function

$$w_i = \frac{R_{\inf}{}^2 - d_i^2}{R_{\inf}{}^2 + d_i^2} \tag{5.1}$$

$$f_m = \frac{\sum_{i=1}^{N_{radar}} w_i \quad f_g(i)}{\sum_{i=1}^{N_{radar}} w_i} \tag{5.2}$$

Where w is the weight given to the data value from the i^{th} radar field; R_{inf} is a pre-specified distance scale which should be equivalent to the furthest range that a valid radar observation can be obtained ; d_i is the distance from the grid point to the i^{th} radar; f_m represents the mosaicked field, and N_{radar}. indicates the number of valid data values available at the grid point.

6. Output

The interpolated and mosaicked radar fields are currently written in data files in Vis5D format. The fields can be displayed by Vis5D or VisAD software. In a Vis5D window, contoured or color-shaded cross sections of gridded data fields can be conveniently viewed and examined.